



National Aeronautics and
Space Administration



Medical Data Architecture

Capabilities and Design

C. Middour¹, M. Krihak², A. Lindsey³, N. Marker⁴, S. Wolfe³, S. Winther⁵,
K. Ronzano⁵, D. Bolles³, W. Toscano³, and T. Shaw³

¹Millennium Engineering and Integration Co, NASA Ames Research Center, Moffett Field, CA

²Universities Space Research Association, NASA Ames Research Center, Moffett Field, CA

³NASA Ames Research Center, Moffett Field, CA

⁴SGT Inc., NASA Ames Research Center, Moffett Field, CA

⁵Wyle Laboratories, NASA Ames Research Center, Moffett Field, CA

2017 NASA Human Research Program Investigators' Workshop

24 January 2017





Overview

- Project Background
- Objectives/Challenges
- System Overview
- Integrated Devices
- Current Status/Next Steps



Project Background

ExMC Element Risk

Risk of Adverse Health Outcomes & Decrements in Performance due to Inflight Medical Conditions

MDA Need

ExMC Gap Med07: We do not have the capability to comprehensively process medical-relevant information to support medical operations during exploration missions.

MDA Goal

The MDA project will develop capabilities that support autonomous data collection, and necessary functionality and challenges in executing a self-contained medical system that approaches crew health care delivery without assistance from ground support.



MDA Project Objectives

- Develop a system to comprehensively manage and process medically-relevant information to support medical operations during exploration missions
- Build a series of test beds that incrementally add capability
- The system will provide the data architecture foundation to:
 - Facilitate autonomous data collection
 - Promote seamless communication with medical and non-medical devices
 - Accommodate data streams in varying formats
 - Provide data management capability for medical operations



Challenges

- Implement NASA Space Flight Human-System Standard NASA-STD-3001
 - Level of Care V: “A high level of potential risk exists that personnel may experience medical problems on orbit at some time during the mission.”
 - Increasing levels of autonomous care
- Limited Resources
 - Medical knowledge and skills (Integrated data/knowledge management)
 - Supplies and equipment
 - No resupply
- Autonomous Crew Medical Operations
 - Delayed communications
 - No ability for medical evacuation
- Accommodate future technologies



Test Bed 1 Overview

Test Bed 1 Objectives

- Demonstrate data flow autonomy
- Establish data architecture foundation
- Develop a scalable data management system
- Utilize modular design and standardized interfaces

Collect Data

- AstroSkin
- Cardiax
- Dose Tracker
- CMO Data Input

Store Data

- Database Population
 - Medical history
 - Biosensors' measurements
 - Medication consumption

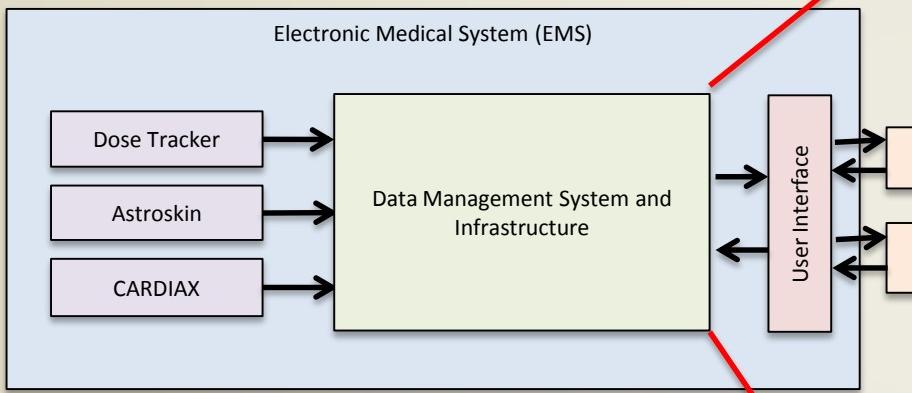
Provide Information

- Display patient medical record
- Display vital signs

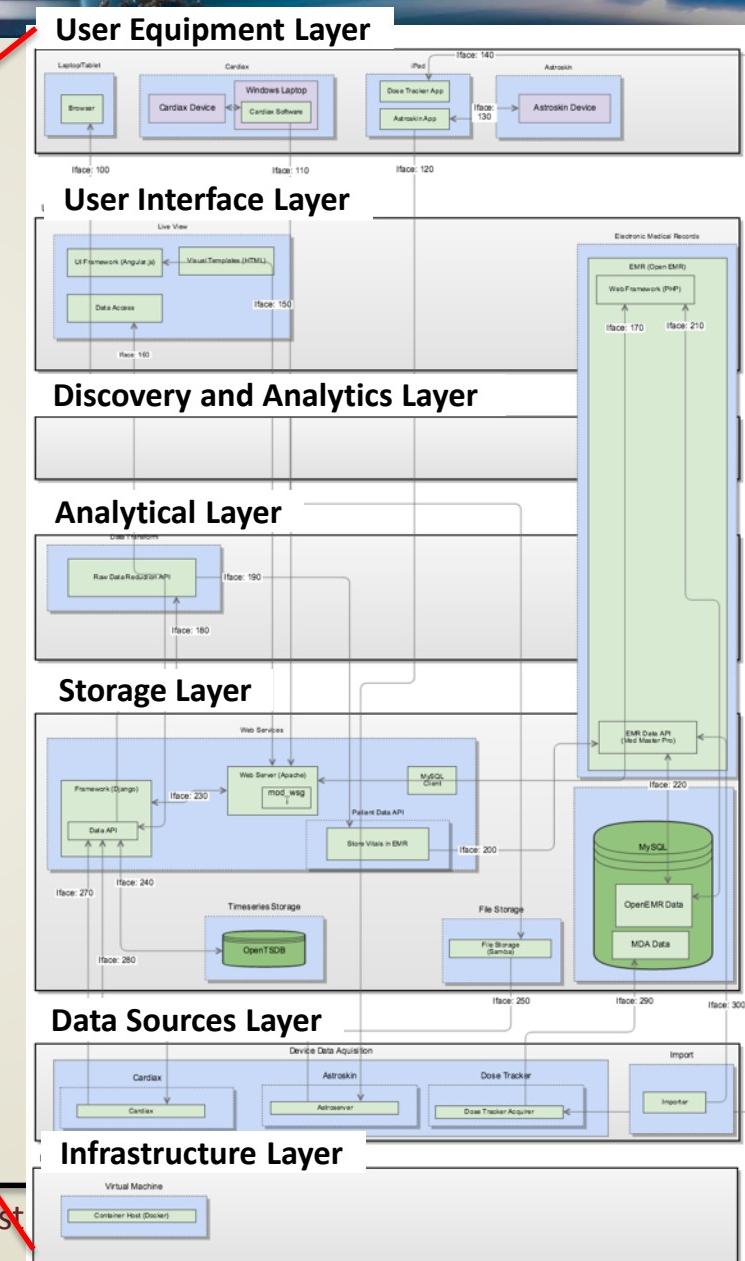
Demo?



MDA Test Bed 1 Functional Block Diagram



- Modular design
 - Layers allow for organization of code and components
 - Biosensor device adapters are modular
- Subsystems separated by interfaces
 - Drop-in replacements of systems in later versions (upgrades, etc)





Software Layers

User Equipment Layer

- Standard web browser (Laptop/Tablet) - **Complete**
- ECG monitor (CARDIAX) - **Complete**
- Wearable biosensor vest for vital signs (Astroskin) - **Complete**
- iPad application currently onboard ISS (Dose Tracker) - **Future Work**

User Interface Layer

- Electronic Medical Records (OpenEMR) - **In Progress**
- Search and display of biosensor data - **In Progress**

Analytical Layer

- Data reduction: reduce streams of heart beat events to a single number - **In Progress**

User Equipment Layer



User Interface Layer



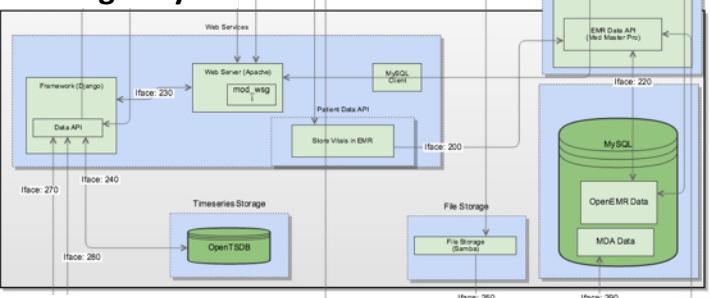
Discovery and Analytics Layer



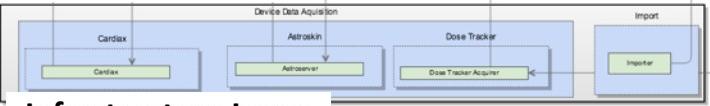
Analytical Layer



Storage Layer



Data Sources Layer



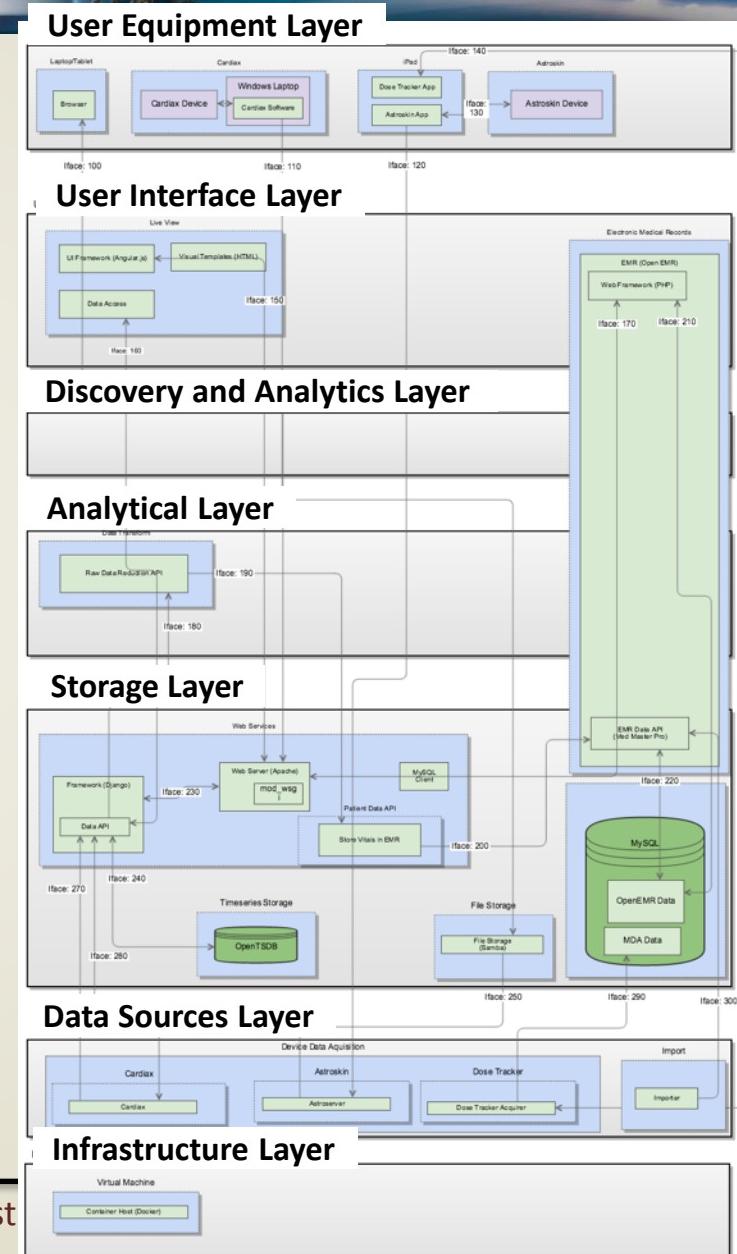
Infrastructure Layer





Software Layers

- **Storage Layer**
 - Data API - [Complete](#)
 - Stores/retrieves biosensor data
 - Backed by relational and time series databases (MySQL, OpenTSDB, HBASE)
- **Data Sources Layer**
 - Software supporting
 - CARDIAX - [In Progress](#)
 - Astroskin - [Complete](#)
 - Dose Tracker - [1.1 Release](#)
 - Crew Data Importer - [In Progress](#)
- **Infrastructure Layer**
 - Server(s) - [Complete](#)
- **Discovery and Analytics Layer**
 - No components in Test Bed 1





System Overview

- Integrates biomedical devices with medical records system
 - “Vitals” and ECG data are automatically populated into EMR
- Software deployment options for development, laboratory and analog testing
 - Hardware (stand-alone servers, “cloud” systems, laptops)
 - Operating System (UNIX, Mac, Windows)
- Automated software build
 - Pre-configures with a standard load of patient data
 - Reduces manual data entry
- Uses open-source components
- NASA Class C software and process



Medical Records System

- Lightly modified open source Electronic Medical Records system “OpenEMR”
 - Integration with biosensor data for auto-populating and plotting data
 - Remove links to insurance billing

NEW PATIENT
Patient History

Default

 Top Bot

Patient: Jared Smith (1)
DOB: 1961-11-26 Age: 55

Encounter History

Selected Encounter: 2016-12-01 (202)

Smith, Jared Delete Reset Onsite Portal Credentials

[History](#) | [Report](#) | [Documents](#) | [Transactions](#) | [Issues](#)

Edit Demographics (collapse)

Who
Contact
Choices
Employer
Stats
Misc

Name: Dr. Jared A Smith
DOB: 1961-11-26
S.S.:351389233

External ID: 1
Sex: Male
License/ID:

Marital Status: Married
User Defined: Jerry Smith

Edit SOAP by Administrator (Collapse)

Subjective: Sub: Patient experiencing some pain and discomforting in anterior region of right shoulder. Occur when using HULK for daily exercise routine. First occurrence was three days prior. Patient describes as a low level of pain that can be felt with increased movement.

Objective: Obj: Patient's vitals are all within normal, healthy limits. Based on assessment, no major issues found. Likely a mild case of bursitis.

Assessment: Ass: Palpation of anterior region shows mild tenderness, but range of motion, strength, and stability are not affected.

Plan: Plan: 440mg of Naproxen for pain and inflammation twice a day for five days. Reduce level of efforts during exercise. Evaluate exercise routine. Follow up after five days.

Edit Patient Encounter by Administrator (Collapse)

Reason: Scheduled private medical conference. Patient has recently completed daily exercise routine. Patient is experiencing low level shoulder pain after using HULK during exercise routine. No other complaints or concerns.

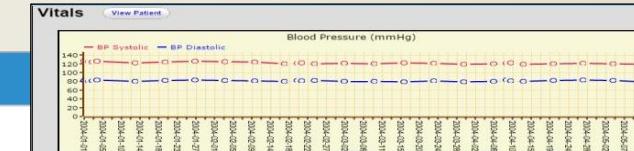
Facility: Prometheus Service

Find:

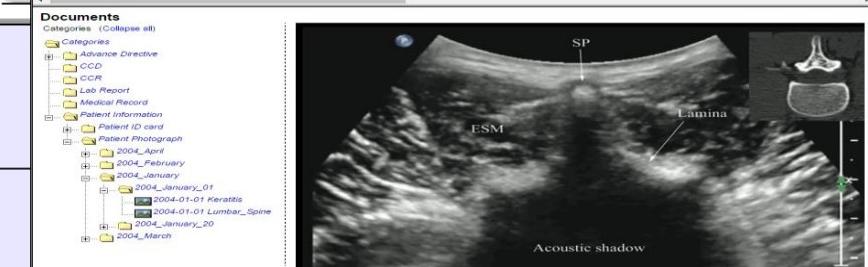
by:

 Name ID
 SSN DOB
 Any Filter

Online Support



Name	Unit	2004-05-11	2004-05-04	2004-04-27	2004-04-20	2004-04-13	2004-04-10	2004-04-09	2004-04-06	2004-03-30	2004-03-23
Weight	lbs	118.00	119.00	118.00	120.00	119.00	118.00	119.00	121.00	120.00	119.00
Weight	kg	53.52	53.98	53.52	54.43	53.98	53.52	53.52	54.88	54.43	54.43
Height	in	62.10	62.10	61.60	61.60	61.60	61.65	61.65	61.70	61.70	61.70
Height	cm	157.73	157.73	156.46	156.46	156.46	156.59	156.59	156.72	156.72	156.72
BP Systolic	mmHg	119	120	121	120	119	122	121	120	119	121
BP Diastolic	mmHg	79	82	83	82	80	81	83	80	79	81
Pulse	per min	50	51	50	51	50	51	52	51	50	50
Respiration	per min	20	19	19	19	18	18	18	18	18	18
Temperature	F	98.80	98.70	98.60	98.70	98.70	98.60	98.80	98.70	98.60	98.50
Temperature	C	37.11	37.06	37.00	37.06	37.06	37.00	37.11	37.06	37.00	36.95
Temp Location		Oral	Axillary								
Oxygen Saturation	%	23	24	22	23	23	22	23	22	23	22
ECG		2	3	4	5	6	7	8	9	10	11



Ultrasound of lumbar spine



Devices

AstroSkin

- Wearable garment-based monitoring system
- Sensors: Accelerometers, 3-lead ECG, respiration, SpO₂, Systolic Blood pressure, skin temperature

CARDIAX

- Wireless, 12-Lead ECG
- ECG Glove: Built-In lead wires attached to pre-positioned electrodes

Dose Tracker

- Collects ISS crewmember medication
 - Usage, dosage, frequency
 - Side effects



Current Status

- Passed gate reviews
 - System Requirements Review (SRR)
 - Preliminary Design Review (PDR) / Critical Design Review (CDR)
 - From the final PDR/CDR board report:
 - “As detailed in the ‘Review Success Criteria Assessment’ section of this report, the project has met, as ‘successful’, all ToR-defined review success criteria.”
 - “ExMC MDA continues to employ a robust incremental phased approach to the Test Beds 1-4, and has documented its technical architecture and allocation of requirements, developed in conjunction with customer’s requirements.”
 - Currently in implementation phase



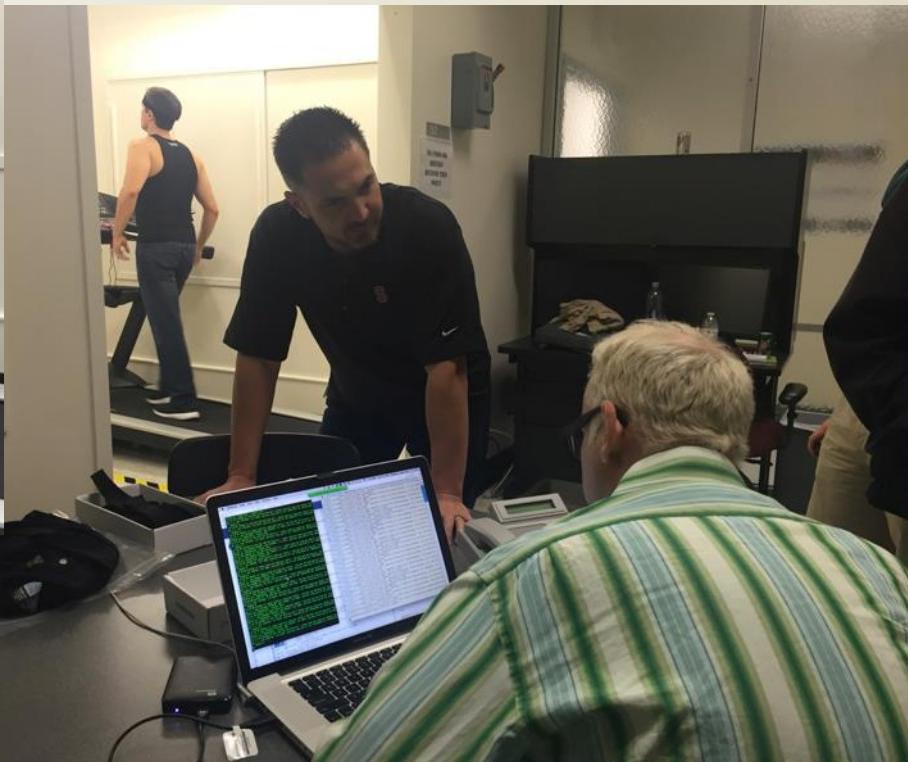
National Aeronautics and
Space Administration



Test Bed 1 in the Lab



ExMC staff execute demonstration at ARC



ExMC staff execute demonstration at ARC



Next Steps

- Scoping potential “Test Bed 1.5” (not baselined)
 - Operate in cooperation with habitat evaluations
 - Integrate exercise device(s)
 - Provide biosensor “telemetry” to spacecraft simulators
- Test Bed 1 Demo – April 2017
- Test Bed 1.0 Release – June 2017
 - Patch Release 1.1 – August 2017 (with Dose Tracker)
- Test Bed 2.0 Scope Completion – July 2017
- Test Bed 2.0 SRR – August 2017